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एक ओर से दूसरी ओर (जिगबैग) संचालन वाले दो केबल वाले रोपवे — रीति संहिता

(दूसरा पुनरीक्षण)

To and Fro (Jig Back) Movement Bi-Cable Ropeways — Code of Practice

(Second Revision)

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Continuous Bulk Conveying, Elevating, Hoisting, Aerial Ropeways and Related Equipment Sectional Committee, MED 06

FOREWORD

This Indian Standard (Second Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Continuous Bulk Conveying, Elevating, Hoisting, Aerial Ropeways and Related Equipment Sectional Committee, had been approved by the Mechanical Engineering Divisional Council.

This standard was first published in 1969 and first revision was done in 2003. This revision has been undertaken to incorporate modifications based on the technology being followed in the country.

An aerial ropeway is a special form of transportation system where passengers/materials are carried using a tensioned wire rope supported above the ground. Aerial ropeways are particularly useful in regions where the facility in surmounting natural barriers gives them a great advantage over railways or roads, both of which may need the heavy civil engineering work to secure easy gradient. They are inexpensive to maintain; pollution free; environment friendly; does not affect aesthetics; their power demand is modest and they are not seriously affected by adverse climatic conditions.

Nothing in this standard is intended to contravene any provisions of the statutory regulations wherever they are in force.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 ‘Rules for rounding off numerical values (*revised*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

TO AND FRO (JIG BACK) MOVEMENT BI-CABLE ROPEWAYS — CODE OF PRACTICE

(Second Revision)

1 SCOPE

1.1 This standard covers the design and construction of the to and fro (jig back) movement bi-cable aerial ropeways for transportation of passengers and goods in separate cabins.

2 REFERENCES

The standards listed in Annex A contain provisions which through reference in the text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards.

3 TERMINOLOGY

For the purpose of this standard, the following definitions in addition to IS 7649 shall apply.

3.1 Jig Back Ropeway — In a ropeway when a single or cluster of chairs/cabins are placed together and the system follows a reversible movement, it is called to and fro or jig back system. Here the system moves from one station to another with a particular direction and on completion of the journey it reverses its direction of movement and the same cycle continues.

The attachment of single or cluster of chairs/cabins with the rope is made on diametrically opposite sides of the carrying rope.

3.2 Line — Route alignment of the ropeway between two terminals.

3.3 Inspecting Authority — Competent Authority recognized by the statutory regulations to inspect the aerial ropeway installation and determine its acceptability or otherwise, on the basis of this standard and in compliance to prevailing statutory rules and regulations.

4 GENERAL REQUIREMENTS

4.1 Guidelines for Design and Construction

4.1.1 Each part of the ropeway equipment shall be designed and constructed in conformity with this standard. The quality of the materials to be used for its construction shall be as per the design.

4.1.2 On the request of the supervising authorities or the purchaser, a certificate of a recognized (NABL/ statutory accredited) testing laboratory shall be supplied by the constructor as regards to the characteristics of material used and essential to the safety of the installation.

4.2 Layout and Freeway

4.2.1 The axis of the line in plan shall be straight. When it is not possible to obtain a straight line, the maximum deviation permitted shall be 0.3°. This effect shall not be cumulative.

4.2.2 The lateral clearance of the cabin on line shall be determined taking into account the cabin dimensions as well as its lateral oscillations of maximum 12°. Obstacles which are not part of the installation shall have a minimum clearance of 1.5 m.

4.2.3 All the towers shall be equipped with guides, which limit the transverse oscillations of the cabins towards the tower to 6° to 8°. For the maximum inclination permitted by a guide, no part of the vehicle shall touch the shoes or any other part of the trestle.

4.2.4 The two tracks of the ropeway shall be so arranged that the minimum free space which separates vehicles inclined towards each other at 12° is at least 1 m, when the span of the rope is not greater than 300 m. As for longer spans, the clearance shall be increased by 0.2 m for each additional 100 m or part thereof.

4.2.5 In the case of spans where the vehicles do not cross each other or in the case of an installation having only one track and with an endless haulage rope, the clearance measured in the horizontal direction between any other rope on opposite path and the vehicle oscillating through 12° in the direction of this rope shall be at least 1 m when the span of any other rope on the opposite path is not greater than 300 m As for longer spans, this clearance shall be increased by 0.2 m for each additional 100 m or part thereof.

4.2.6 In the longitudinal direction, the vehicles shall be capable of free swinging by about 19^{o} with reference to the vertical.

4.2.7 The minimum vertical clearance between the space occupied by vehicle and the terrain lying below with obstacles existing over it, such as trees, rocks, snow drifts, etc, referred to the lowest outline of the vehicle shape and determined taking into account the most unfavourable conditions shall be at least 1.5 m when the place over which the vehicle passes is not accessible to the public. Where this is not possible, this vertical clearance shall be at least 2.5 m measured from the lowest part of the cabin after considering the longitudinal and transverse oscillation referred in **4.2.5** and **4.2.6**.

4.2.8 When there are crossings with other communication paths or with overhead electric lines, a minimum clearance shall exist in order to take into account the requirements of **4.7**.

4.3 Maximum Speed

4.3.1 The speed of the ropeway shall be determined in such a way that the safety of travel is ensured. In no case shall the maximum speed exceed the values given below:

a) For attended cabins : 12 m/s in line and 10 m/s over trestles

b) For unattended cabin : 7 m/s in line and 6 m/s over trestles

4.3.2 The maximum braking capacity should be determined based on the maximum speed selected. This speed shall be such that all the energy contained in the vehicle and the corresponding wire ropes can be transformed into heat without any reduction in the braking effort or any damage to the brake.

4.4 Capacity of Vehicles

4.4.1 *Capacity*

4.4.1.1 The calculation of the various elements shall be done taking into account the weight of 70 kg per passenger in the case of cabins with maximum capacity of 15 passengers and 65 kg per passenger in the case of cabins with capacity greater than 15 passengers. In the case of ropeway transporting passengers for wintersports or climbing installations, these weights shall be increased by 10 kg per person to take into account supplementary equipment of the passengers.

4.4.1.2 Each vehicle with a capacity of more than 15 passengers shall be accompanied by a conductor.

4.4.1.3 The area at the disposal of the each standing passenger shall be at least 0.22 m^2 up to 15 passengers and 0.18 m^2 for each person above 15 passengers. The minimum height inside the cabin shall be 2 m.

4.5 Rope Guiding

4.5.1 The permanency of the carrying wire rope on the shoes shall be ensured even under the most unfavourable conditions. The minimum load on the shoe shall be at least 50 percent greater than the force which would be necessary to unseat the rope taking into account a gust of wind, as per IS 875.

4.5.2 The moving wire ropes shall be protected by guides, or any other devices, that in the case of transverse wind, these wire ropes conserve their normal position in the sheaves on which they are resting. In addition, the sheave, guide, or other devices shall be of such shape that the rope is prevented from any displacement that may result in entanglement of the wire rope.

4.5.2.1 At a level lower than that of the carriage bottom, a support for the haulage ropes, which might slip off, should be provided on the trestles.

4.5.2.2 Where the moving cable is not supported on a sheave, it shall be generally supported by a roller train whose number depends on the total load exerted by the wire rope at the point under consideration. The permissible load for a roller without a soft material lining shall be 200 kgf and the maximum permissible angle of deflection shall be 2°30′. When the rollers are lined with soft lining, the value of the permissible load may be increased according to the quality of the material (for example, for good quality rubber lining, the maximum load in kgf can reach the value of 4 × wire rope diameter × roller diameter where the diameters are expressed in cm). But in no case, shall the angle of deflection exceed 4°30′. In the case where the wire rope makes an arc of circumference of the sheave, the requirements of shall also be taken into account. All the rollers shall be mounted on rolling bearings.

4.6 Rescue of Passengers Along the Line

4.6.1 If the aerial ropeway passes over inaccessible terrain or if the height of the vehicles over the ground does not permit rescue of the passengers by direct descent by means of ladders or ropes, a relief cabin operated from a station shall be provided.

4.6.2 In favourable conditions, upto 20 m, it is sufficient to provide ladders or equipment, which permits descent by rope. This equipment for descent shall be readily available in the cabin when no other means of safety of passenger is provided.

4.7 Crossings

4.7.1 The crossing of routes, roads, railways, waterways or other ropeways shall be avoided as far as possible. When it is not possible, the clearance shall be

determined in such a manner that there is no danger for any vehicle using the various ways enumerated.

4.7.2 The crossings and paralleling with railways, highways, cableways or overhead electric lines shall be so done that no mutual discomfort results either in the course of normal operation or rescue operation or during installation operations. Wherever the local conditions are favorable and the characteristics of the electric lines permit it, the overhead electric lines shall be replaced by underground cables.

4.7.3 Long paralleling with electric overhead lines or contact lines shall be avoided, as far as possible. The distance of separation shall be determined in such a way that the safety of both installations is ensured. Any phenomenon of induction shall not in any way affect the continuity or integrity of the telephonic or safety systems on either of the installations.

4.8 Dangerous Areas

4.8.1 In the proximity of airports or in areas where aeroplanes fly at low altitude or land frequently, the route of the ropeways shall be adequately marked, taking into account any restriction imposed by the authority having jurisdiction over the airports.

4.8.2 The areas exposed to the dangers of natural forces (avalanches, landslides, falling rocks, storms, earthquakes, etc.) shall be avoided as far as possible.

4.8.3 If the dangers indicated in **4.8.2** exist, suitable protective devices shall be provided.

4.9 Wind Action

4.9.1 The wind forces and their effects (static and dynamic) shall be taken into account when designing ropeways. The provisions mentioned in IS 875 (Part 3) and in IS 802 (Part 1) shall be followed.

4.9.2 In the calculation of wind action on the cables, the surface area to be considered shall be the diametric surface of the cable multiplied by the factor (C_w) given below:

a) $C_w \approx 1.1$ for snow bound areas, and
b) $C_w \approx 0.7$ for areas not affected by snow.

4.9.3 The uplift caused by the breeze/wind on the wire rope and the carrier shall be considered with the conditions specified in **4.5.1** are fully met.

5 WIRE ROPES

5.1 General

5.1.1 As far as possible, all wire ropes shall be in single piece and shall be of non-rotating construction. Welded joints in the rope shall be spaced at least 6 times the pitch of the wire and their number in 500 m length shall not exceed the number of wires in the wire rope.

5.1.2 Before the wire ropes are put into service, they shall be checked by a suitable non-destructive method like magneto inductive test, to ensure that the requirement given in **5.10** are fully met. Such tests shall be carried out periodically by any Government approved lab or test house accredited by NABL/ statutory regulations.

5.1.3 Lubricants incorporated in the wire rope during manufacturing shall not exert any corrosive action on the material of the rope. Lubrication of the rope during service shall be done according to the specific requirements.

5.1.4 Care shall be taken to avoid any twisting or kinking of the rope during unreeling the rope or in service.

5.2 Carrying Wire Ropes

5.2.1 Only full-locked coil ropes shall be used.

5.2.2 The minimum braking strength of the wire rope at the time of putting into service shall not be less than 3.3 times the maximum axial load met with in service calculated for the most unfavourable condition or circumstances.

5.2.3 When the effect due to braking of the vehicle does not exceed 15 percent of the maximum tension, this load may be neglected. For calculation purposes, the coefficient of friction between the wire ropes and the shoe in bronze or similar material can be taken equal to 0.10 for locked coil ropes and 0.15 for stranded wire ropes. For steel shoes, these coefficients shall be increased by 20 percent. For calculating the normal load to which the carrying wire ropes are subjected, the load on the rollers defined in **5.7.1** shall be taken into account in addition to the requirements of **5.3.2**.

5.3 Haulage and Ballast Wire Ropes

5.3.1 Stranded wire ropes of fiber or solid plastic core are suitable.

5.3.2 The minimum breaking strength of the haulage and ballast wire rope shall be at least 4.5 times the maximum tensile load met with in service. In the calculation of the maximum tensile load the most unfavourable combination of circumstances shall be taken into account. Loads due to atmospheric influence and due to wind may be neglected.

5.4 Tensioning Ropes

5.4.1 The tensioning ropes shall be of the ordinary lay type with a single layer of strands or have full locked coil type. Ropes of the Lang's lay type may be used

only, if the rotation of either the counter-weights or the coupling to the carrying traction rope is prevented.

5.4.2 The minimum breaking strength of the tensioning or regulating ropes shall be at least 5.5 times the maximum axial load in the rope during operation.

5.5 Telephonic and Signal Wire Ropes

5.5.1 The telephonic and signal wire ropes shall be of the stranded type and protected against corrosion. Wire rope of any other construction is permissible provided the safety of operation is ensured.

5.5.2 The minimum breaking strength of the wire ropes shall be not less than 3.3 times the maximum axial load met within service.

5.5.3 Care shall be taken to ensure that the telephonic and signal cables do not come into contact either with the vehicles or with the carrying-hauling rope even under the worst conditions of weather. Therefore, if these cables are connected with line trestles, the height of the support shall be so chosen as to avoid any interference between the cables and vehicles or carrying-hauling ropes which can affect the safety and regularity of operation.

5.6 Auxiliary Wire Ropes

5.6.1 The auxiliary wire ropes are generally stranded wire ropes.

5.6.2 The minimum breaking strength of the rope shall be not less than 3.3 times the maximum tensile load met with in service.

5.7 Loads on Sheaves, Drums and Saddles

5.7.1 *Normal Load*

5.7.1.1 The number of carriage rollers shall be such that the maximum load on any one of them does not exceed one-eightieth of the minimum tension for the carrying cable at the point considered. It is recommended that a ratio between the normal load in the cable produced by the vehicle and the minimum tension of the carrying cable not exceeding one-twelfth is adopted.

5.7.1.2 For normal loads in moving wire ropes, the requirements of **4.5.2.2** shall be taken into account.

5.7.2 *Sheaves, Drums and Shoe*

The fixed drum to which the anchorage of carrying ropes are secured by friction shall have a diameter of not less than 65 times that of the wire rope and 1 000 times that of the outer wires of the wire ropes. The wire rope should at least make three rounds of the drum and it should be served at least by two fasteners at the outlet, of which one assures the proper fixation and the second serves to check the slip of the wire rope, if any, and functions as the safety device.

5.7.2.1 The diameter of the pulleys of the tensioning devices to which the carrying ropes fixed directly to the counter weights shall be at least 100 times that of the wire rope.

5.7.2.2 The radius of the roller and returns for tensioning the wire ropes fixed directly to the counter weights shall be not less than 100 times that of the wire ropes and 1 200 times that of the wires of the wire ropes.

5.7.2.3 The diameter of deflection pulleys of stranded stretch wire rope shall be not less than 40 times that of the wire rope and at least 600 times that of the wire in the outer layer of the wire rope. These pulleys shall be provided with linings in leather, wood or any other relatively soft material.

5.7.2.4 The diameter of the driving and return sheaves shall be not less than 80 times that of the hauling rope and at least 800 times that of the wires of the wire rope.

5.7.2.5 The support saddles which support the carrying rope shall present such a profile that while passing the trestles any danger or sliding of vehicle is avoided. They have to ensure the equilibrium tension in the wire rope and to permit free displacement of the wire rope in the longitudinal direction when necessary, by making use of the rollers. The radius of curvature of saddle supports shall be at least 300 times that of the wire rope diameter.

5.7.2.6 The radius of curvature of the saddle supports shall be adapted to the speed at the passing of the trestles. To this end, the following requirements shall be satisfied:

$$\frac{V_s^2}{R} < 2 \text{ m/s}^2$$

where

V_s = the speed over the trestles, in m/s; and

R = the radius of curvature of saddle support, in m.

Where necessary, the speed shall be reduced to bring the value to the permissible value computed as above while passing over the saddle.

5.8 Splices and Rope Termination

5.8.1 Experienced personnel shall make all splices. The length of a splice shall not be less than 1 300 times of the rope diameter. The distance between two contiguous splices shall not be less than 3 600 times the diameter of the rope. However, two additional splicing may be permitted in case of repair after an accident.

5.8.2 Rope-socketing shall be done with utmost care. Only organizations which have experience in making

of rope sockets shall be entrusted with this operation.

5.9 Testing and Acceptance of Ropes

5.9.1 Testing and acceptance of ropes shall conform to the relevant Indian Standards.

5.10 Discarding Criteria for Ropes

Generally a rope should be withdrawn from service when it is considered that:

a) the loss of strength in the rope due to wear or corrosion or both is approaching one-sixth of the original strength;
b) the loss of strength in the rope due to fatigue, surface embrittlement or cracked and broken wires of any kind is approaching one-tenth of the original strength;
c) the outer wires have lost about one-third of their depth as result of any kind of deterioration;
d) the outer wires are becoming loose and displaced for any reason;
e) the rope has become kinked, distorted or damaged and the damaged piece cannot be removed;
f) examination of the rope leaves any doubt as to its safety for reason whatsoever; and
g) number of wires rupture in the rope exceed the limit specified in **8.1.6** of IS 3973.

6 STATIONS

6.1 General

6.1.1 According to the climate of the area where the ropeways are situated, suitable shelters for passengers and personnel shall be provided at stations as agreed to between the manufacturer and the buyer. In every case, such shelter shall be conforming to local statutory regulation.

6.1.2 The station machinery such as mechanical parts of the driving gear, electrical equipment, ropes and vehicles shall not be a source of danger to the passengers and ropeways personnel.

6.1.3 The whole of the driving gear and of the return or deflection devices shall be protected against bad weather. In addition, care shall be taken to prevent the entrance to the machine room of unauthorized persons to avoid any possible accident to them.

6.1.4 The ropeway operator shall be located, where he shall have the best possible view of the route. The controls and communicating devices shall be within the reach without his having to leave his position.

6.1.4.1 The control panel shall be provided with the following:

a) Speed indicator,
b) Indicator showing the distance from any one of the terminal station, and
c) Fault indicator.

6.1.4.2 A speed control device which automatically stops the vehicle when the speed of the vehicle approaching the station has not been suitably reduced, shall be provided.

6.1.5 Fire hazard shall be reduced as far as possible. Fire extinguishers as per local area regulations guaranteed to function effectively shall be kept ready in case of need and installed in places which are readily accessible.

6.2 Driving and Braking

6.2.1 The driving gear shall be provided with an emergency system fed by auxiliary power which shall be used only for rescue/evacuation operation.

6.2.2 The speed of the system shall be maintained constant irrespective of any load conditions. To this end, the speed shall be regulated to +4 percent, whatever is the load.

6.2.2.1 The main driver shall also regulate the speed of the system in such a way as to ensure at lower speed while entering the station and when necessary over the trestles.

6.2.2.2 Starting of the system even under the most unfavourable conditions of load shall be guaranteed.

6.2.2.3 In the event of power failure, passenger transportation shall be forbidden unless hundred percent power backup is provided.

6.2.2.4 In the case of downward load, the driver itself shall exert a continuous braking action.

6.2.3 Travel with the main motor shall be stopped automatically when any brake is on or if any safety device operates.

6.2.4 *Rope Adhesion on the Driving Sheave*

6.2.4.1 The friction coefficient (μ) between the rope and the surface of the groove of the driving sheave are as follows:

a) Groove without lining (cast iron or steel) $\mu = 0.07$
b) Groove with leather lining $\mu = 0.15$
c) Groove with rubber or similar material with high friction coefficient $\mu = 0.25$
d) Groove with aluminum lining may also be used for which value of μ to be agreed between

the ropeway promoter and the Inspecting Authority.

6.2.4.2 The contact angle of the rope on the driving sheave shall be such as to ensure that in the most unfavourable combination of circumstances the required power is transmitted to the rope.

6.2.5 As far as possible, belts shall not be used for power transmission. However, in the case of small powers (less than 10 HP) use of V-belts shall be permitted provided at least four belts are used simultaneously for transmitting the power.

6.2.6 Two different friction brakes with independent source of power shall be used in case of electric motor drive to cause both the normal stopping and emergency one. One of these brakes is called 'service brake' fitted on gearbox input shaft and the other is 'emergency brake', fitted on drive sheave. Each of such brakes shall be able to ensure the safe stopping of the installation's motion under most unfavourable conditions of loading. In any case, the nominal average deceleration shall not exceed 0.5 m/s^2.

6.2.6.1 To avoid sudden braking with all the consequent and undesirable oscillation of vehicles, it is recommended that the braking effort should be proportionate to the load conditions of the line and applied in gradual manner.

6.2.6.2 The emergency brake shall act directly on the driving sheave; springs shall induce its braking effort and its operation shall be carried out in a manner that its regular working can be automatically and constantly checked. This brake shall act automatically if the speed of the carrying- hauling rope exceeds the permitted value by 15 percent. It shall also be capable of being released manually. Emergency brake for ropeways on plain terrain may be deleted, if, the ropeways stops on its own without the application of an external brake.

6.2.6.3 The 'service brake', besides ensuring the holding of the driving gear when the installation is stopped, shall work when the feeding power fails or in case of overload of the ropeway. Moreover, it shall also work automatically when the remote control stops are activated or when any safety device is operated (*see* **6.2.3**).

6.2.6.4 The factor of safety of all parts forming the brakes shall not be less than 5.

6.3 Rope Tensioning and Anchorage Devices

6.3.1 The spaces in which the counterweights travel (in pit or construction above the ground) shall be protected from water, snow, and ice and from any other material. It shall be ensured that the above elements do not accumulate inside these spaces. These spaces shall be provided with guard-rails in order to prevent the entrance of unauthorized persons.

6.3.2 The mobility of the counterweights shall be ensured at all times.

6.3.3 The travel of the counterweight shall be determined taking into account the maximum variation which may be due to the sag of each span, the surrounding temperature of the zone where the installation lies (minimum variation to be considered is 60°) and the elastic stretch of the rope.

6.3.4 Where several tensioning ropes are laid in parallel, all the necessary precautions shall be taken in order to ensure uniform distribution of the tension among such ropes.

6.3.5 In place of tension ropes, chains can be used. The safety factor shall be at least 7 in this case. Other systems are permissible subject to agreement between the ropeway promoter and the inspecting authority.

6.3.6 The foundations of either tensioning devices in these of the anchorage shall have a factor of safety of 1.5 in respect of shifting and over turning. Such factor of safety is to be calculated on the basis of a conventional assumption that these foundations are free, that is, there is no lateral movement of the earth.

6.3.7 All foundations shall be in accordance with IS 4091. For the structural safety against sliding, overturning and for the footings at different levels provisions laid down in IS 1904 shall apply. The depth of footings and other provisions shall conform to the provisions laid down in the relevant Indian Standards depending on the type of foundation [*see* IS 1904, IS 1080, IS 2950, IS 11089, IS 9456, IS 2911 (Part 1/ Sec 1), IS 2911 (Part 1/Sec 2), IS 2911 (Part 1/Sec 3), IS 2911 (Part 1/Sec 4), IS 2911 (Part 3)].

6.3.8 In all above application hydraulic tensioning system may also be used.

6.4 Other Requirements

6.4.1 In stations, the vehicles shall be guided in such a manner that at the entrance or exit of passengers no lateral unbalancing is produced.

6.4.2 In terminal stations, current interrupters shall be provided at the end of the vehicle travel.

6.4.3 Equipment meant for maneuvering of wire ropes and other mechanical and electrical equipment shall be provided in stations.

6.4.4 The platforms shall be provided with parapets wherever it is necessary to avoid accidents to persons.

6.4.5 Rope pulleys shall be manufactured from high quality cast iron, malleable cast iron or steel and shall be mounted on rolling bearings.

7 TRESTLES

7.1 Loads

In designing trestles, the following stress values shall be taken into account:

a) The weight of the trestle and the pressure exerted by the ropes;
b) The whole of the stresses due to friction met with during the motion of the moving ropes and during the displacement of a stationary rope;
c) Weight of the vehicles travelling with maximum load (considered conventionally static load);
d) Wind load or snow load; and
e) Load imposed by communication cable, if provided.

7.1.2 The wind forces and their effects (static and dynamic) should be taken into account when designing ropeways. The provisions mentioned in IS 875 (Part 3), IS 802 (Part 1) shall be followed. Further, loads due to snow in accordance with IS 875 (Part 4) shall also be considered while designing ropeways. The ropeway design shall also consider seismic loads in accordance with IS 1893. In addition, other special loads in accordance with IS 875 (Part 5) shall also be considered while designing ropeway.

7.2 Safety

7.2.1 The metal parts of the trestle shall have a safety factor defined as the ratio of the ultimate strength of the metal to stress in the metal under the most unfavourable conditions of not less than 3.0 when the installation is in service.

7.2.2 The trestle shall be analyzed and designed for various load combinations as per IS 802. The trestle foundation shall be either a shallow foundation or deep foundation or founded on rock anchors. These foundations shall be in accordance to **6.3.7**.

7.2.3 The elastic deformation of the trestles, in particular those due to torsion which happens during normal conditions of operation, shall not be such as to endanger the safety of the guides and the stability of the ropes. The maximum angle of deformation due to torsion shall be limited in such a manner that the ends of the shoes for supporting the carrying-hauling rope are not displaced by more than 20 percent of the wire rope diameter.

7.3 Construction

7.3.1 The number of trestles, their position, their height and their construction are determined by the requirements of the route and the layout. Wooden trestles or trestles which are guyed shall not be used.

7.3.2 In case the trestles have metallic framework, the thickness of the open profile shape shall not be less than 5 mm while in the case of closed profile; it shall not be less than 2.5 mm. The interior of the latter shall be adequately protected against corrosion.

7.3.3 The anchorage of the trestles on the concrete foundations or on the rock shall be carefully made. The anchor bolts of concrete foundations shall just be at least 300 mm above natural ground level.

8 VEHICLES

8.1 Factor of Safety

For all components constituting the vehicles, the factor of safety shall be at least 5 under both static and dynamic conditions.

8.2 Construction

8.2.1 The vehicle shall be suspended in such a manner that whatever be the slope of the track, the cabin remains suspended in the vertical position.

8.2.2 The vehicle shall be so designed that even when it is empty and under the wind pressure for which it is designed, the transversal inclination of the vehicle with the reference to the vertical does not exceed 20 percent.

8.2.3 All transparent panes used in the vehicle shall be of minimum 3 mm thickness and made of either safety glass, polycarbonate or acrylic sheet.

8.2.4 It shall be ensured that the cabin door remains closed during travel and cannot be opened from inside by the passengers.

8.2.5 The weight of the vehicle shall, as far as possible, be equally distributed on all the rollers of the carriage. The roller shall be lined with soft materials such as rubber/neoprene rubber/nylon and mounted on bearings.

8.3 Brakes

8.3.1 The vehicle shall be provided with an automatic carriage brake, which acts on the carrying rope or on a static rope called the brake rope in the case of breaking of a haulage or ballast rope. This brake shall be capable of manual operation by the operator also. It should also be capable of being disengaged by the operator after it has functioned.

8.3.1.1 Vehicles may be designed without track brakes provided the following conditions are fully met:

a) Irrespective of the gradient of the ropeway a ballast rope shall be provided;
b) The factor of safety of the haul rope shall be maintained at least 20 percent higher than that adopted for haul ropes of systems with track brakes and it should not be less than 5.5;
c) The haul rope should be tested by magneto-inductive method once every six weeks or 300 working hours whichever is less. If after some period of use it is found that 50 percent of the replacement criteria of the rope has been met then the time gap between rope testing should be halved to 3 weeks or 150 h;
d) The fixing of the carriage with the haul rope is done by a gripping mechanism designed with at least two independent elements acting simultaneously. The gripping mechanism shall not use the gravity effect of the weight of the carrier to achieve the gripping force;
e) The griping elements are so designed that even with the complete failure of one of the elements the other should achieve a resistance to slipping equal to 150 percent of the sliding force of the loaded carrier at the steepest point of the ropeway line;
f) The griping mechanism is so designed that its condition and status can be easily verified during daily checks;
g) The gripping point of the carriers are to be moved along the rope by a distance of at least the total distance covered by the griping mechanism or 1 m whichever is more. This shifting shall be done once in every three months period. The shifting should always be in the same direction along the rope;
h) The depth of grooves of the carriage rollers to be maintained at least 40 percent of the nominal diameter of the track rope. Provision is also to be made to prevent build-up of dirt, dust etc. in the roller groove by providing scrapers etc; and
j) At least two rope guides are provided in the carriage such that they extend beyond the underside of the track rope by a distance of half the diameter of the track rope.

8.3.2 The braking effort shall be such that the value of deceleration produced is sufficient in all cases even under the most unfavourable conditions of loads and slope to ensure complete braking.

8.3.3 The braking shall be such that even when the conditions of the brake are favourable to jolting of the vehicles under no load, the brake provided shall be such as to avoid any jolts.

8.4 Lighting Equipment

Each vehicle shall be provided with relief lights.

9 COMMUNICATIONS, SAFETY CIRCUITS AND EARTHING OF METALLIC PARTS

9.1 Communications

9.1.1 The stations shall be linked to each other by telephone. At least one of the stations shall be linked up with the public network, wherever the latter exists.

9.1.2 Communication facilities (telephone or wireless) shall be provided in the vehicle for communication with the driving station or with the second vehicle. Other safety devices shall be provided for help in case of the failure of the telephone.

9.2 Safety Circuit

9.2.1 All the safety devices along the length of line and in the stations shall be incorporated in the continuous circuit energized permanently so that when any one device fails or the signal line fails, the system automatically comes to a halt.

9.2.2 The haulage ropes and the ballast ropes shall be isolated from the earth so that in case of brake or derailment, the shortcircuit produced, if these come in contact with earthen members, automatically brings the vehicle to stop and brake the installation.

9.2.2.1 Alternatively suitable sensing devices or limit switches may be incorporated in the haul rope support arrangement such that any haul rope derailment or adverse positioning of the haul rope causes such sensors or limit switches to be activated and a stop signal generated to bring the system to a halt.

9.3 Earthing

9.3.1 All the metallic portions of the installation with an exception of auxiliary ropes, signal ropes, ballast and haulage ropes shall be directly earthed.

9.3.2 The entire ropeways system shall be provided with suitable protection against lightning.

10 SAFETY REQUIREMENTS

10.1.1 The cabins must be provided with door lock, which cannot be opened by the passengers.

10.1.2 Two separate brakes shall be provided in the drive of ropeway system. One brake is provided on drive sheave. This will act as emergency brake. A second brake is provided on high speed shaft which will act as service brake. The brakes must come in operation automatically when:

a) normal stop/emergency stop push button is pressed;

b) the ropeway speed exceeds by 5 percent of the set speed;

c) the tripping of drive motor due to actuation of line and station security devices; and

d) in case of power failure.

10.1.3 The vehicle shall be provided with an automatic carriage brake, which acts on the carrying rope or on a static rope called the brake rope in the case of breaking of haulage or ballast rope. This brake shall be capable of manual operation by the operator also. It should also be capable of being disengaged by the operator after it has functioned. Vehicles without track brakes may be designed without a track brake provided the conditions as laid down in **8.3.1.1** are fully met.

10.1.4 Arrangement should be made so that the brakes can be released during emergency running of the system.

10.1.5 Standby prime mover is required to run ropeway at slow speed, to rescue passengers from line in case of failure of main motor or power failure or DG set failure.

10.1.6 Line safety devices must be installed on each trestle which immediately stop the ropeway in the unlikely event of rope derailment.

10.1.7 Rope catcher must be provided in the roller batteries forming part of the saddles.

10.1.8 Emergency push buttons must be provided at all stations to stop the ropeway.

ANNEX A

(*Clause* 2)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*
802 (Part1) : 2015	Code of practice for use of structural steel in overhead transmission line towers: Part 1 Materials, loads and permissible stresses,
(Sec 1) : 1995	Materials and loads
(Sec 2) : 1992	Permissible stress
875 (Part 3) : 2015	Code of practice for design loads (other than earthquake) for buildings and structures: Part 3 Wind loads
(Part 4) : 1987	Snow loads
(Part 5) : 1987	Special loads and load combinations
1030 : 1998	Carbon steel castings for general engineering purposes
1080 : 1985	Code of practice for design and construction of shallow foundations in soils (other than raft, ring and shell)
1089 (Part 2) : 1986	Steel wire ropes for aerial ropeways — Specification : Part 2 Track ropes
1804 : 2004	Steel wire ropes — Fiber main cores — Specification
1893 : 1984	Criteria for earthquake resistant design of structures
1904 : 1986	Code of practice for design and construction of foundations in soils General requirements
2062 : 2011	Hot rolled medium and high tensile structural steel
2911 (Part 1)	Code of practice for design and construction of pile foundations: Part 1 Concrete piles,
(Sec 1) : 2010	Driven cast *in-situ* concrete piles
(Sec 2) : 2010	Bored cast *in-situ* piles
(Sec 3) : 2010	Driven precast concrete piles
(Sec 4) : 2010	Bored precast concrete piles
2911 (Part 3) : 1980	Code of practice for design and construction of pile foundations: Part 3 Under-reamed piles
2950 (Part 1) : 1981	Code of practice for design and construction of raft foundations: Part 1 Design
3973 : 1984	Code of practice for the selection, installation and maintenance of wire ropes
4091 : 1979	Code of practice for design and construction of foundation for transmission towers and poles
7649 : 1975	Glossary of terms used in connection with aerial ropeways and cableways
9456 : 1980	Code of practice for design and construction of conical and hyperbolic paraboloidal types of shell foundations
IS 10891	Steel wire ropes for aerial ropeways:
(Part 1) : 2001	Haulage ropes
(Part 2) : 1986	Track ropes
11089 : 1984	Code of practice for design and construction of ring foundation
14329 : 1995	Malleable iron castings

ANNEX B

(*Foreword*)

COMMITTEE COMPOSITION

Continuous Bulk Conveying, Elevating, Hoisting, Aerial Ropeways and Related Equipment Sectional Committee, MED 06

Organization	*Representative(s)*
RITES Limited, Gurgaon	Shri Rajiv Milind (***Chairman***)
Central Institute of Mining and Fuel Research (CIMFR), Dhanbad	Shri Debasis Basak Shri Girendra M. Prasad (*Alternate*)
Conveyor Ropeway Services Pvt Ltd, Kolkata	Shri S. Shekhar Chakravarty Shri Kamal Kumar Bose (*Alternate*)
Damodar Ropeways and Infra Ltd, Kolkata	Shri Ranjan Mukherjee
Directorate General of Mines Safety, Dhanbad	Shri D. B. Naik Shri Vijay Kumar K. (*Alternate*)
Directorate General Factory Advice Service and Labour Institute, (DGFASLI), Mumbai	Shri U. K. Das Shri H. Chattopadhyay (*Alternate*)
Elecon Engineering Co Ltd, Vallabh Vidyanagar	Shri C. S. Shah Shri K. S. Kodia (*Alternate*)
Indian Association of Amusement Parks & Industry, New Delhi	Shri Pradeep Sharma Shri Balwant Chawla (*Alternate*)
Mcnally Bharat Engineering Co Ltd, Kolkata	Shri Shyamal Kumar Das Shri Ashoke Kumar Bose (*Alternate*)
MECON Limited, Ranchi	Shri A. K. Ghosh Shri jaipal singh (*Alternate*)
Ministry of Shipping New Delhi	Shri B. Poiyaamozhi Shri D. J. Basu (*Alternate*)
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National Thermal Power Corporation Ltd, New Delhi	Shri O. P. Kalia Shri B. K. Bhattacharya (*Alternate*)
Phoenix Conveyor Belt India (P) Ltd, New Delhi	Shri Rajeev Sharma Shri Asoke Kumar Ghosh (*Alternate*)
Polo amusement Park Ltd, Gurgaon	Shri Santosh Chawla
Projects and Development India Ltd, Dhanbad	Shri Narendra Singh
Rail India Technical and Economic Services Ltd, (RITES), Gurgaon	Shri A. Bhadra Shri N. C. Srivastava (*Alternate*)
Ropeway and Resorts Pvt. Ltd, Kolkata	Shri A. K. Kinra
Steel Authority of India Ltd (IPSS SECT), New Delhi	Shri S. K. Bose Shri R. K. Anand (*Alternate*)
USHA BRECO Limited, Ghaziabad	Shri Sanjeev Dhariwal Shri Manoj Panwar (*Alternate*)
In personal capacity (*145/4A, South Sinthi Road, Kolkata-700050*)	Shri C. K. Karmakar
In personal capacity (*F-7B, DDA MIG Flats, Hari Nagar, New Delhi-110006*)	Shri S. C. Gandhi
BIS Directorate General	Shri A. Renga Rajan, Scientist 'E' and Head (MED) [Representing Director General (*Ex-officio*)]

Member Secretary
Shri A. K. Mohindroo
Scientist 'C' (MED), BIS

Panel 1 on Aerial Ropeways

Organization	*Representative(s)*
RITES Limited, Gurgaon	Shri A. Bhadra (***Convener***)
CIMFR, Dhanbad	Dr D. Basak
Conveyor & Ropeway Services Pvt Ltd, Kolkata	Shri K. K. Bose
DGMS, Kolkata	Shri D. B. Naik
Damodar Ropeways and Infra Ltd, Kolkata	Shri Ranjan Mukherjee

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